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*Full Length Research Paper*

# An examination of technical, allocative and economic efficiencies in *Ofada rice* farming in Ogun State, Nigeria

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**The need to improve efficiency of rice production is accentuated through high level of importation of rice needs in Nigeria. This paper examined technical, allocative and economic efficiencies in *Ofada* rice farming in Ogun state, South-West Nigeria and determined factors affecting them among others. A total of 192 rice farmers were sampled through a multi-stage sampling procedure. Data were analyzed using descriptive statistics, stochastic frontier analysis (SFA) and tobit regression analysis. The average areas cultivated to rice was 0.86 ha. Majority (60%) of the farmers had contact with extension workers while 56% had no access to credit. Bird invasion, finance and unavailability of tractors were the most striking problem confronting *Ofada* rice farming in the opinion of the farmers. The return to scale value of 1.29 estimated from the SFA revealed that farmers were operating in stage I of the production surface, hence, the need to employ more resources in order to maximize benefits. The mean technical, allocative and economic efficiencies were 0.726, 0.928 and 0.674, respectively. It was therefore concluded that rice farmers can still increase output or save cost without the need to change existing technology. Furthermore, extension contact and education were found to be very crucial to efficient rice production.**

**Key words:** Efficiencies, production, rice, output, return-to-scale, Nigeria.

## INTRODUCTION

The food sub-sector of Nigerian agriculture parades a large array of staple crops, made possible by the diversity of agro-ecological production systems. Out of these staple crops, rice has risen to a position of preeminence. Since the mid-1970s, rice consumption in Nigeria has risen tremendously, at about 10% per annum due to changing consumer preferences (Akande, 2007). It was further stated that domestic production has never been able to meet the demand, leading to considerable imports which stand at about 1,000,000 metric tons yearly. The imports are procured on the world market with Nigeria spending annually over US$300 million on rice imports alone. According to FAOSTAT (2008), Nigeria is the largest importer of rice on the African continent and the second largest importer in the world. Projected growth in rice consumption for Nigeria beyond year 2008 remained as high as 4.5% per annum. About three billion people eat rice everyday around the world while Nigerians presently consume over four and half million tonnes of rice annually.

*Ofada* rice is a popular local upland rice grown in Ogun state and other states in South-West Nigeria. This rice hitherto was un-patronized. In the last decade however, consumption of *Ofada* rice has gained more prominence possibly due to its positive taste and natural flavor, higher nutritive value compared to polished rice, higher fibre content and health consideration. Consequently, it now commands the highest market price given its scarcity relative to other rice varieties including imported ones.

Inefficiency in rice production has been identified as one of the factors contributing to low productivity in agricultural production in Nigeria. The presence of shortfalls in efficiency means that output can be increased without the need for new technology. If this is

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the case, then empirical measures of efficiency are necessary in order to determine the gains that could be obtained by improving performance in rice production with a given technology. An important policy implication stemming from significant level of inefficiency is that it might be more cost effective to achieve short term increases in farm output, and thus income by concentrating on improving efficiency rather than on the introducetion of new technology (Akinbode, 2010).

In the light of the afore-mentioned difficulty, this study was thus carried out with the objectives of determining the productivity of rice production. It also estimated the technical, allocative and economic efficiencies of *Ofada* rice farming in the study area. Finally, factors affecting the estimated efficiencies were also determined.

## Theoretical framework

### *Productivity and production efficiency*

The process of transforming inputs into outputs is called production (Adegeye and Dittoh, 1985). The term productivity refers to the efficiency with which production inputs are transformed to output in a production process. It measures the rate of technical change in production (Chambers, 1988). Growth in productivity implies an expansion of the production possibility frontier, implying that a given stock of fixed and variable inputs will be able to produce more of a particular output without having to reduce outputs of other commodities.

### *Technical efficiency (TE)*

From the output perspective, TE measures the potential increase in output, keeping the inputs constant. From the input perspective, it measures the ability of the firms to produce a given output using the smallest set of inputs. TE is associated with the ability to produce on the frontier isoquant. It is attained when the best available technology is used to achieve maximum output possible (Farrel, 1957)

### *Allocative efficiency (AE)*

According to Farrel (1957), this can be referred to as price efficiency. From the output perspective, allocative efficiency is simply the revenue maximizing problem while from the input perspective it is a measure of firm's ability to allocate input bundle or produce a given level of output in the cost minimizing way. It holds when resource allocation decisions minimize cost, maximize revenue, or more generally maximize profit.

### *Economic efficiency (EE)*

Combining measures of technical efficiency and allocative efficiency yields a measure of economic efficiency. EE is defined as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology (Farrel, 1957).

### Specification of the stochastic frontier production model

The stochastic frontier production function model for estimating farm level technical efficiency is specified as:

$$Y_i = f(X_i;\beta) + \varepsilon_i \quad i = 1,2,\dots\dots\dots n \qquad (1)$$

Where $Y_i$ is the output, $X_i$ denotes the actual input vector, β is the vector of production function and ε is the error term that is composed of two elements, that is:

$$\varepsilon = V_i - U_i \qquad (2)$$

Where $V_i$ is the symmetric disturbances assumed to be identically, independently and normally distributed as $N(0,\sigma^2_v)$ given the stochastic structure of the frontier. The second component $U_i$, is a one-sided error term that is independent of $V_i$ and is normally distributed as $(0, \sigma^2_u)$, allowing the actual production to fall below the frontier but without attributing all shortfalls in output from the frontier to inefficiency:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \qquad (3)$$

Furthermore, $$\gamma = \frac{\sigma_u^2}{\sigma^2} \qquad (4)$$

The variance ratio parameter γ (Gamma) according to Battesse and Cora (1977) ranges between zero and one. (That is, $0 \leq \gamma \leq 1$).

The variance ratio parameter γ has two important characteristics:

1. When $\sigma_v^2$ tends to zero, then u is the predominant error in Equation (1) and γ tends to 1, implying that the output of the sampled farmers differs from the maximum output mainly because of difference in technical efficiency.
2. When $\sigma_u^2$ tends to zero, then the symmetric error v is the predominant error in equation (1) and so γ tends to 0. Thus based on the value of γ, it is possible to identify whether the difference between a farmer's output and the efficient output is principally due to random errors (γ tends to 0) or the inefficient use of resources (γ tends to 1) (Kalirajan, 1981).

Following Jondrow et al. (1982), the technical efficiency estimation is given by the mean of the conditional distribution of inefficiency term Ui given $\varepsilon_i$; and thus defined by:

$$E(U_i|\varepsilon_i) = \frac{\sigma_u\sigma_v}{\sigma}\left[\frac{f\left(\frac{\varepsilon_i\lambda}{\sigma}\right)}{1-f\left(\frac{\varepsilon_i\lambda}{\sigma}\right)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \quad (5)$$

Here $\lambda = \frac{\sigma_u}{\sigma_v}$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ while $f$ and F represents the standard normal density and cumulative distribution function respectively evaluated at $\varepsilon_i\lambda/\sigma$.

The farm specific technical efficiency is defined in terms of observed output ($Y_i$) to the corresponding frontier output ($Y_i$*) using the available technology derived from the result of Equation (5) as:

$$TE = \frac{Y_i}{Y_i^*} = \frac{E(Y_i|U_i,\ X_i)}{E(Y_i|U_i = 0,\ X_i)} = E[\exp(-U_i|\varepsilon)] \quad (6)$$

Therefore, TE = exp (-$U_i$)

TE takes values ranging from zero to one, where 1 indicates a fully efficient farm.

The stochastic frontier cost functions model for estimating farm level overall economic efficiency is specified as:

$$C_i = g(Y_i, P_i; \propto) + \varepsilon_i \quad i = 1,2,3, \ldots .n \quad (7)$$

Where $C_i$ represents the total production cost, Yi represents the output produced, Pi represents the prices of inputs, α represents the parameters of the cost function and $\varepsilon_i$ represents the error term that is composed of two elements, that is:

$$\varepsilon = V_i + U_i$$

However, because inefficiencies are assumed to always increase costs, error components have positive signs (Coelli et al., 1998).

The farm specific economic efficiency (EE) is defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C) using the result of Equation 5. That is:

$$EE = \frac{C_i}{C_i^*} = \frac{E(C_i|U_i = 0,\ Y_i\ P_i)}{E(Y_i|U_i,\ Y_i\ P_i)} = E[\exp(-U_i|\varepsilon)] \quad (8)$$

Here EE takes values between 0 and 1.

Hence a measure of farm specific allocative efficiency (AE) is obtained from technical and economic efficiencies estimated as:

$$AE = \frac{EE}{TE} \quad (9)$$

This means that 0 ≤ AE ≤ 1.

## METHODOLOGY

### The study areas

Ogun state is located in the Southwest corner of Nigeria and was created in 1976. It is located within latitudes 3°30'N - 4°30'N and longitudes 6°30'E-7°30'E. The state covers a land area of 16,762 square kilometer with a population of 3,728,098 in 2006. The climate of the state follows a tropical pattern with the raining season starting around March and ending in October, followed by dry season. The mean annual rainfall varies from 1,050 mm in the northern areas which has derived savanna vegetation to 1,280 mm in the southern parts of the state which has mangrove swamp vegetation. The average monthly temperature ranges from 23°C in July to 32°C in February. The state has a fertile soil that supports the growth of rice, cowpea, yam, cassava, plantation, banana, citrus, vegetables, cocoa, kola nut, rubber, oil palm and sugarcane. Some farmers in the state also engage in livestock production such as poultry, cattle, goat and sheep.

### Sampling technique, sample size and method of data collection

Multi-stage sampling technique was used to select rice farmers for this study. The first stage involved a purposive selection of the Abeokuta Zone of the Ogun State Agricultural Development Programme - OGADEP (OGADEP, the state's agricultural extension agency divided the state into four agricultural administrative zones for ease of agricultural extension services) which is known for *Ofada* rice cultivation. The second stage involved the random selection of one Local Government Area from the zone. Ewekoro Local Government Area was selected in this respect. In the third stage, twenty villages were randomly selected from the Local Government Area. The fourth stage featured the selection of ten *Ofada* rice farmers from each village in the local government area through random selection. This gave a total number of 200 *Ofada* rice farmers. The total number of questionnaires used for analysis represented 96% (192 questionnaires) of the total number of sampled rice farmers as 8 were discarded. Personal interview was used to elicit data from respondents using structured questionnaires as interview guide. Data were collected on socio-economic characteristics of rice farmers, rice production data (such as resources used, costs, returns, prices, and constraints to rice production among others).

### Analytical techniques

#### *Descriptive statistics*

This was used to describe the socioeconomic characteristics of rice farmers and problems confronting rice farming in the study area.

#### *The stochastic production frontier approach*

A Cobb-Douglas functional form was employed to model *Ofada* rice production technology in this study, due to the following reasons: (a) the functional form has been used in many empirical studies, particularly, those relating to developing country agriculture (Ajibefun et al., 2002; Bravo-Ureta and Pinheiro, 1997); (b) the functional form also meets the requirement of being self-dual, that is, allowing an examination of economic efficiency. The Cobb-Douglas functional form for the rice farms in the study areas is specified as follows for the production functions (here, output is specified as a function of technical inputs and the error term):

$$InY_i = \beta_0 + \beta_1 InX_{1i} + \beta_2 InX_{2i} + \beta_3 InX_{3i} + \beta_4 InX_{4i} + \beta_5 InX_{5i} + \beta_6 InX_{6i} + V_i - U_i \quad (10)$$

Where, Y = Output of rice (kg); $X_1$ = Farm Size in hectares; $X_2$ =

**Table 1.** Summary statistics of variables in the SFA model and other socioeconomic variables.

| Variable | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| Output (Kg) | 1470.00 | 780.00 | 650.00 | 2240.00 |
| Farm size (ha) | 0.86 | 0.48 | 0.24 | 2.10 |
| Hired labor (workdays) | 67.00 | 23.45 | 21.00 | 110.00 |
| Family labor (workdays) | 113.50 | 51.20 | 42.00 | 202.00 |
| Fertilizer (kg) | 169.00 | 75.45 | 50.00 | 300.00 |
| Seed quantity (kg) | 88.64 | 35.50 | 40.10 | 190.00 |
| Pesticides (litres) | 1.15 | 0.75 | 0.50 | 3.50 |
| Age in years | 44.63 | 13.01 | 22.00 | 68.00 |
| Years of schooling | 7.50 | 4.00 | 0.00 | 12.00 |
| Household size | 7.00 | 3.00 | 1.00 | 14.00 |
| Years of rice farming experience | 23.00 | 17.00 | 2.00 | 44.00 |

Family labor in workdays (One workday is equivalent to 8 h of an adult male work, for female and children appropriate conversion factors were used); $X_3$ = Hired labour in workdays; $X_4$ = Seed in kg; $X_5$ = Fertilizer in kg; $X_6$ = Pesticides in litres; Vi = random variable which is assumed to be independently and identically distributed (iid) $N(0,\sigma_v^2)$ and independent of U; Ui = non-negative random variable associated with technical inefficiency in production, and is assumed to be independently and identically distributed half normal (iid) $N(0,\sigma_u^2)$ where the conditional mean μ is assumed to be related to farm and farmers-related socioeconomic characteristics as follows:

The inefficiency model is specified thus:

$$\mu = \delta_0 + \delta_1 W_1 + \delta_2 W_2 + \delta_3 W_3 + \ldots\ldots\ldots\ldots\ldots + \delta_8 W_8 \quad (11)$$

Where, $W_1$ = Age of farmer in years; $W_2$ = Age-squared; $W_3$ = Educational level of farmer (number of years spent in school); $W_4$ = Household Size; $W_5$ = Years of Rice farming experience; $W_6$ = Extension contact (1 if the farmer has extension contact, 0 if otherwise); $W_7$ = Access to credit (1 if farmer has access to credit, 0 if otherwise); $W_8$ = Gender of farmer (1 if male, 0 if otherwise).

#### Economic efficiency and allocative efficiency

In order to estimate economic and allocative efficiencies of the rice farmers, a Cobb-Douglas cost frontier function for rice farms in the study area was specified as:

$$InC_i = \alpha_0 + \alpha_1 InP_{1i} + \alpha_2 InP_{2i} + \alpha_3 InP_{3i} + \alpha_4 InP_{4i} + \alpha_5 InP_{5i} + V_i + U_i \quad (12)$$

Here C is total production cost of rice per farmer for the season; $P_1$ is the rental value of land per hectare for the season; $P_2$ is the wage rate of labor per workday; $P_3$ is the price of rice seed per kilogram; $P_4$ is the price of fertilizer per kilogram; $P_5$ is the price of pesticide per litre; $\alpha_s$ are parameters estimated. The frontier cost function was estimated using maximum likelihood methods. For this study, the computer programme FRONTIER version 4.1 was used.

According to Ogundari and Ojo (2006) the computer programme estimates the cost efficiency (CE), which is computed originally as the inverse of Equation 8. Hence, farm-level economic efficiency (EE) was obtained as the inverse of CE using the relationship:

$$EE = \frac{1}{Cost\ Efficiency\ (CE)} \quad (13)$$

Factors affecting Allocative and Economic Efficiencies were determined using a Tobit Model because the values were restricted between 0 and 1. This procedure was adopted by Bravo-Ureta and Pinheiro (1997).

The model is stated thus:

$$EFF_j = \delta_0 + \delta_1 W_1 + \delta_2 W_2 + \delta_3 W_3 + \ldots\ldots\ldots\ldots\ldots + \delta_8 W_8 \quad (14)$$

Where $EFF_j$ is the vector of the $j^{th}$ efficiency index (j = 1 for AE, and 2 for EE).

## RESULTS AND DISCUSSION

### General characteristics of the *Ofada* rice farmers

The average age of farmers was 44.6 years with majority completing primary school education with average years of rice farming experience of 23 (Table 1). An average farmer in the study area realized an output of 1.47 t (an equivalent of 1.7 t/ha). This is far below the average yield of 4 t/ha which is known in literature. The standard deviation value of 780 (in kg), shows that there is a great inequality in the output of the farmers, as shown by the large dispersion around the mean. The farmers cultivate relatively small areas of land with a mean value of 0.86 ha. They used much of family labor than hired labor. The level of fertilizer use was very low (an average of 169 kg on an average farm size of 0.86 ha; that is, 196.5 kg per ha). Furthermore, the low level of fertilizer and herbicide use may reduce output of *Ofada* rice substantially. None of the farmers use herbicide; therefore farmers relied on manual weeding, which may result in labor wastage and decrease efficiency. Table 2 shows that majority (60%) of the farmers had contact with extension workers, while

**Table 2.** Distribution of farmers by extension contact, access to credit and problems confronted in rice farming.

| Variables | Frequency | Percentage |
|---|---|---|
| ***Extension contact*** | | |
| No contact | 76 | 39.60 |
| Have contact | 116 | 60.40 |
| Total | 192 | 100.00 |
| | | |
| ***Access to credit*** | | |
| Have access | 84 | 43.80 |
| Have no access | 108 | 56.30 |
| Total | 192 | 100.00 |
| | | |
| ***Problems confronted*** | | |
| Birds | 192 | 100.00 |
| Insects | 23 | 14.20 |
| Rodents | 169 | 88.00 |
| Untimely delivery of Fertilizers | 84 | 43.80 |
| Finance | 180 | 93.80 |
| Unavailability of tractors | 192 | 100.00 |

Source: Field survey.

**Table 3.** Labor use pattern by operation.

| Labor use by operation | Labor (workdays) | Total labor use (%) |
|---|---|---|
| Land clearing | 29.20 | 16.20 |
| Planting | 25.50 | 14.20 |
| Fertilizer application | 4.80 | 2.70 |
| Insecticide application | 2.30 | 1.30 |
| Weeding | 38.20 | 21.20 |
| Bird scaring | 30.50 | 16.90 |
| Harvesting | 49.80 | 27.60 |
| Total | 180.30 | 100.00 |

Source: Computed from field survey data.

majority (56%) had no access to credit. Invasion of rice destroying birds (*Quela spp.*), finance and unavailability of tractors were the most important problems confronting rice farmers (Table 2).

## Labor use pattern on rice farms

The labor use patterns by operation in *Ofada* rice farms revealed that harvesting consumed an average of 49.84 workdays (58 workdays per hectare that is, 27.6% of total labor use). Bird scaring took an average of 30 man-days on an average of 0.86 ha that is, 35 workdays per hectare (16.9%), land clearing (16%), weeding (21%) and planting (14%). The proportion of labor used in bird scaring is high given the fact that bird scaring did not contribute directly to production (Table 3). This underscores the need for urgent control measures against bird invasion in rice farms in Nigeria. An attempt either by technological invention aimed at controlling bird invasion on rice farms is capable of significantly raising rice output.

## Productivity analysis for *ofada* rice farmers

Table 4 presents the estimated parameters for the stochastic production functions for the rice farmers considered in the study. Estimates of the parameters of the stochastic frontier production model revealed that all the estimated coefficients of the variables of the production function were positive. The positive coefficient of farm size, hired labor, seed, fertilizer and insecticide implies that rice output increases with increase in these variables. Family labor and insecticide did not exert any significant effect on rice output as shown by their t-ratio values. The implication of this is that increase in the level of use of family labor and insecticide will not increase output of rice in the study area. The return to scale (RTS) analysis which serves as a measure of total resource productivity is given in Table 6. The RTS parameter (1.209) is obtained from the summation of the coefficients of the estimated inputs (elasticities) which indicates that rice production in the study area was in the Stage I of the production surface. Stage I is the stage of increasing positive return to scale. This implies that efforts should be made by the farmer to expand the present scope of rice production to actualize the potential in it. More of the variable inputs (especially land) could be employed to obtain more output. The RTS reported in this study was

**Table 4**. Stochastic production function estimation for *Ofada* rice farms.

| Variable | Parameter | Coefficient | T-ratio |
|---|---|---|---|
| Constant | $\beta_0$ | 1.282** | 2.411 |
| Farm size | $\beta_1$ | 0.970** | 2.146 |
| Family labor | $\beta_2$ | -0.780 | -0.311 |
| Hired labor | $\beta_3$ | 0.029** | 2.084 |
| Seed | $\beta_4$ | 0.447*** | 2.608 |
| Fertilizer | $\beta_5$ | 0.281*** | 5.542 |
| Insecticide | $\beta_6$ | 0.262 | 1.071 |
| **Inefficiency model** | | | |
| Age | $\delta_1$ | 0.016 | 0.052 |
| Age-squared | $\delta_2$ | 0.053 | 0.021 |
| Education | $\delta_3$ | -0.185*** | -2.725 |
| Household size | $\delta_4$ | 0.291 | 0.942 |
| Experience | $\delta_5$ | -0.128 | -0.719 |
| Extension contact | $\delta_6$ | -2.109* | -1.763 |
| Credit | $\delta_7$ | 1.525 | 1.331 |
| Gender | $\delta_8$ | 2.314* | 1.942 |
| Sigma-squared | $\sigma^2 = \sigma_u^2 + \sigma_v^2$ | 0.423** | 2.131 |
| Gamma | $\gamma = \sigma_u^2 / \sigma^2$ | 0.979*** | 3.222 |
| Log Likelihood function | LLF | 13.700 | |

*** P < 0.01; ** P < 0.05; * P<0.1. Source: Computed from field survey data.

**Table 5.** Stochastic cost function estimation for rice farms.

| Variables | Parameters | Coefficient | T-ratio |
|---|---|---|---|
| Constant | $\alpha_0$ | 8.381*** | 8.356 |
| Land price | $\alpha_1$ | 0.717*** | 3.938 |
| Labour price | $\alpha_2$ | 0.885** | 2.140 |
| Seed price | $\alpha_3$ | 0.407 | 0.621 |
| Fertilizer price | $\alpha_5$ | 0.180*** | 3.560 |
| Insecticide price | $\alpha_6$ | 0.060** | 2.156 |
| Sigma-squared | $\sigma^2$ | 0.061* | 1.890 |
| Gamma | $\gamma$ | 0.969*** | 19.35 |

*** P < 0.01; ** P < 0.05; * P<0.1. Source: Computed from field survey data.

**Table 6.** Elasticities and return to scale (RTS) analyzes of production functions.

| Variables | Elasticities |
|---|---|
| Farm size | 0.970 |
| Family labour | -0.780 |
| Hired labour | 0.029 |
| Seed | 0.447 |
| Fertilizer | 0.281 |
| Insecticide | 0.262 |
| Return to scale (RTS) | 1.209 |

Source: Field survey data.

very close to the value of 1.26 reported by Ajibefun (2002) in a study among Nigerian farmers. Ogundari and Ojo (2005) also reported a close value of 1.115 among mixed-crop farmers in Nigeria. In this vein, Ogundari and Aladejimokun (2006) reported an RTS value of 1.238 among small holder cocoa farmers in Ondo state, South-West Nigeria. These implied that the value reported in this study is not an isolated case, thereby further underscoring the need to expand scope of agricultural production.

The estimates of the stochastic frontier cost function are presented in Table 5. The results revealed that all the independent variables conform to the a priori expectations as all the estimated coefficients (land price, labor price, seed price and insecticide price) gave positive coefficients. This means that as these factors increased total production cost increased ceteris paribus. The result of the t-ratio test shows that all the variables were statistically different from zero at 5% level of significance except price of seed. This means that increases in seed price would not increase the total cost of production significantly.

## Efficiency analysis for *ofada* rice production in study area

### *Technical efficiency*

Efficiency analysis of rice production in the area revealed

**Table 7.** Predicted technical, economic and allocative efficiencies of rice farmers.

| (a)Ogun Upland | Technical | | Economic | | Allocative | |
|---|---|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent | Frequency | Percent |
| 0.301 – 0.400 | 3 | 6.30 | - | - | - | - |
| 0.401 – 0.500 | - | - | 3 | 6-30 | - | - |
| 0.501 – 0.600 | 9 | 18.80 | 11 | 22.90 | - | - |
| 0.601 – 0.700 | 12 | 25.00 | 10 | 20.80 | - | - |
| 0.701 – 0.800 | 5 | 10.40 | 15 | 31.30 | 3 | 6.30 |
| 0.801 – 0.900 | 10 | 20.90 | 9 | 18.80 | 10 | 20.80 |
| > 0.900 | 9 | 18.80 | - | - | 35 | 72.90 |
| Mean | 0.726 | | 0.674 | | 0.928 | |
| Minimum | 0.371 | | 0.409 | | 0.740 | |
| Maximum | 0.996 | | 0.850 | | 0.985 | |

Source: Computed from field survey data.

that technical inefficiency effects existed in rice production in the study area as confirmed by the gamma value of 0.979 that was significant at 1% level (Table 4). The gamma ($\gamma$) ratio indicates the relative magnitude of the variance $\sigma^2$, associated with the technical inefficiency effects. Therefore, the gamma value of 0.979 implies that about 98% variation in the output of rice farms was due to differences in the technical inefficiencies of the rice farmers. The predicted technical efficiencies (TE) ranged between 0.371 and 0.996 with a mean TE of 0.726 (Table 7). The wide variation shows possibility for improvement by some farmers. The mean TE in this study is above that of Myint and Kyi (2005) which was 0.64 for small (< 5 acres) farms in irrigated rice farms in Myanmar Germany using a stochastic frontier production function. Okoruwa et al. (2006) reported a mean TE of 81.6% among the upland rice farmers in Niger state North Central Nigeria. Ajibefun (2002) reported a mean TE of 0.63. The result in this study implies that if the average farmer in the sample was to achieve the technical efficiency of his most efficient counterpart, then the average farmer could realize a 27.1% cost saving (that is, 1 – (0.726/0.996) or increase in output. A similar calculation for the most technically inefficient farmer in this study reveals increase in output of 62.8% (that is, 1 – (0.371/0.996). Table 7 shows the distribution of farmers according to technical efficiency.

The parameter estimates from the inefficiency model included in the stochastic production frontier estimation revealed that extension contact and education have significant negative effect on inefficiency. This implies that farmers who claimed to have frequent contact with extension agents and more educated rice farmers were more technically efficient than those who claimed not to have frequent contacts with extension agents and had lower levels of formal education. The positive value of gender coefficient means that male farmers were less technically efficient than their female counterpart. It should be recalled that male were scored 1 in the quantification of the dummy variable (gender) while females were scored zero. The positive effect of both extension contact and education on technical efficiency (as revealed by their negative effects on inefficiency) of rice farmers in the study is in line with *a priori* expectations. This is because both variables are expected to directly or indirectly raise the awareness, sense of objective evaluation and the possibility of use of improved techniques of production. This also underscores the importance of education and extension services in raising rice production through improvement in the technical knowledge of rice farmers in Nigeria. Overtime, a number of governmental and non-governmental organizations including the World Bank have invested heavily in extension training in the country. The significance of the gender variable underscores the need for directional policy intervention targeted at male farmers in order to raise rice production efficiency. Ajibefun (2002) study revealed that education and years of farming experience had negative effect while age of farmers and family size had positive effect on technical inefficiency. Furthermore, Ogundari and Ojo (2007) found out that education, experience and credit availability had a significant negative effect on technical inefficiency among small scale food crop farmers in Nigeria.

### *Economic efficiency*

The analysis revealed that there was economic inefficiency effect as shown by the gamma value of 0.969 in the cost function which was significant at 1% level (Table 5). This implies that about 96.9% of the total variation in total cost of production incurred by each farmer was due to differences in their cost inefficiencies.

**Table 8.** Tobit model of determinants of allocative and economic efficiencies.

| Variables | Economic | | Allocative | |
|---|---|---|---|---|
| | Coefficient | t-ratio | Coefficient | t-ratio |
| Age | -1.178*** | -3.090 | -0.910** | -2.447 |
| Age squared | 0.021*** | 3.642 | 0.018** | 2.240 |
| Education | 1.157*** | 3.679 | 0.899*** | 3.082 |
| Households size | 1.291 | 0.652 | 1.103 | 0.909 |
| Experience | -0.529*** | -2.936 | -0.601*** | -3.327 |
| Extension | 8.670*** | 4.616 | 7.696*** | 4.059 |
| Credit | -0.784 | -0.868 | -0.099 | -0.109 |
| Gender | -0.052 | -0.051 | -2.485** | -2.133 |
| Log-likelihood function | 30.44 | | 23.65 | |
| Sigma-squared | 0.00088 | | 0.00244 | |

Source: Computed from field survey data.

The predicted economic efficiency (EE) of the farmers ranged between 0.409 and 0.85 with a mean value of 0.674 (Table 7). This implies that if the average farmer is to achieve the economic efficiency of his most efficient counterpart, the average farmer could realize a 20.7% cost saving (that is, (1 – (0.674/0.85)). This also means a cost saving of 51.9% for the most economically inefficient farmer (that is, ( 1 – (0.41/0.85)).

### *Allocative efficiency*

The predicted allocative efficiency of farmers ranged between 0.74 and 0.985 with a mean value of 0.928. This means that if the average farmer was to achieve the allocative efficiency level of his most efficient counterpart, the average farmer could realize a cost saving of about 5.8% while the most allocatively inefficient farmer could realize a cost saving of about 24.9%. Table 7 shows the distribution of farmers according to their predicted allocative efficiencies.

### Factors affecting allocative and economic efficiencies

Since efficiency generally ranges between zero and one, the tobit model developed by Tobin (1958) and used by Bravo-Ureta and Pinheiro (1997) was used to analyze the effects of various socioeconomic characteristics of the farmers on the rice farming efficiency. Table 8 shows the estimates of the tobit model of the factors affecting farm level allocative and economic efficiencies in the study area:

1. Economic efficiency: Age-squared ($\alpha_{0.01}$) and educational level ($\alpha_{0.01}$) of the household heads had significant positive effects on economic efficiency (Table 8). The older the farmer the more experienced he was expected to be and this ultimately will aid decision making on the farm business thus resulting in production of more output at reduced cost. Education is expected to provide formal knowledge which may help farmers in developing better managerial skill to aid decision making on the farm. Bravo-Ureta and Pinheiro (1997) found contract farming, reform beneficiary status, farm size and farmers' age being positively affecting economic efficiency among peasant farmers in the Dominican Republic.
2. Allocative efficiency: Age ($\alpha_{0.01}$) and experience ($\alpha_{0.01}$) had significant negative effects on allocative efficiency contrary to expectation. These imply that older and more experienced farmers were not efficient in their cost minimizing techniques in relation to input price differentials and allocation of production resources. Meanwhile age-squared ($\alpha$ = 0.01), education ($\alpha$ = 0.01) and extension contact ($\alpha$ = 0.01) had a positive effect on allocative efficiency. These underscore the importance of non-formal education in form of extension services in agricultural production. In the Bravo-Ureta (1997) study, contract farming, reform beneficiary status, farm size and farmers' age had positive effect on AE while household size had negative effect on AE.

## CONCLUSION AND RECOMMENDATION

The result of the SFA revealed that basic production variables included in the production functions had positive relationship with rice output. In the same vein, the maximum likelihood cost function showed that prices of variable cost items contributed significantly to the total cost of production. The production function estimations revealed a RTS value of 1.209. This means that *Ofada* rice farmers were operating in stage I of the production surface and that more production resources could be employed to maximize benefits.

The means of TE, AE and EE values were 0.726, 0.928, and 0.674 respectively. Given the shortfall in the technical efficiencies of farmers, there is substantial potential to improve output of an average farm without the need for any change in existing technology. Moreover, the means for TE, AE and EE means that farmers still have the potential to achieve some level of cost savings or increase in output if certain corrective measures are taken as inefficiency effects still existed among the sampled rice farms. It should be noted that it is sometimes cheaper to increase output by focusing on factors that cause inefficiency than introducing new technology which may require more sophisticated and expensive equipments. A major issue to note from these analyses is the fact that allocative efficiency was more significant than technical efficiency as a source of gains in Economic Efficiency. Finally, one of the crucial issues highlighted by this study is that labour is the most significant cost item in the rice farming enterprise and the reduction in the workdays expended could turn around the fortune of the enterprise positively, especially the work-hours used in bird scaring, planting and harvesting the farms.

The study therefore recommends the following:

1. Researches in agricultural and mechanical engineering should focus more on inventing affordable and effective bird scaring equipment/machines.
2. Credit should be provided to farmers in the form of agricultural input subsidies. Such inputs like fertilizers, herbicides, insecticide and tractors for hiring should be delivered timely when it will be useful for rice farming operations.
3. Extension services should be strengthened to cover more villages and settlements.

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